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METALS TECHNOLOGY LABORATORIES

ANODIC DISSOLUTION TESTING OF WELDING INSTITUTE OF CANADA (WIC) SPECIMENS

R.J. BRIGHAM AND V. MITROVIC-SCEPANOVIC

MTL 89-64(TR)

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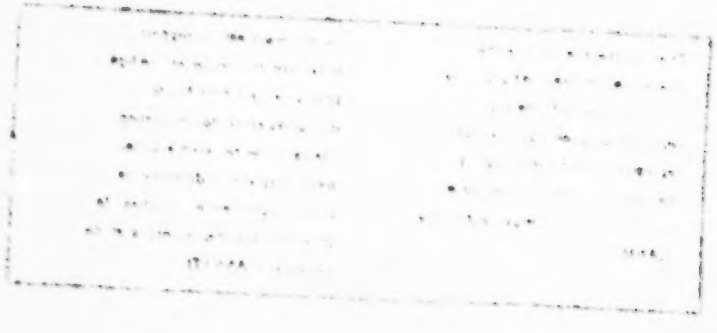

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METALS TECHNOLOGY LABORATORIES

REPORT MTL 89-64(TR)

ANODIC DISSOLUTION TESTING OF WELDING INSTITUTE OF CANADA (WIC) SPECIMENS

by

R. J. Brigham and V. Mitrovic-Scepanovic

ABSTRACT

Galvanostatic anodic dissolution testing was carried out at CANMET on samples supplied by WIC to clarify the effect of C, Mn, Nb and heat input on preferential heat-affected zone corrosion.

LABORATOIRES DE LA TECHNOLOGIE DES METAUX

RAPPORT: MTL 89-64(TR)

EVALUATION DES ECHANTILLONS DE L'INSTITUT DE SOUDAGE DU CANADA EN UTILISANT L'EPREUVE DE DISSOLUTION ANODIQUE

par

R. J. Brigham and V. Mitrovic-Scepanovic

RESUME

L'épreuve galvanostatique de dissolution anodique a été appliquée à CANMET sur des échantillons provenant de L'Institut de Soudage du Canada pour claritier le rôle de C, Mn, Nb et l'apport calorifique vis-à-vis la corrosion accelérée dans la zone affectée par la chaleur.

INTRODUCTION

CANMET, along with Algoma, Nippon and Stelco, sponsored a research project at WIC to carry out a fundamental study of the parameters responsible for preferential heat-affected zone (HAZ) corrosion in ship plate steels. The grid of alloys investigated consisted of high and low concentrations of Mn, C and Nb welded with high and low heat input. Compositions are given in Table 1. In all cases, the welding consumable was a high Ni SAW SD1-3Ni with OP121TT flux - a combination known to be resistant to weld metal attack based on previous CANMET work (1). Welding parameters are listed in Table 2.

In the WIC evaluation(2), published by Savva et al(3), anodic dissolution tests were carried out on the butt-welded specimens at a constant potential of -500 mV vs SCE for 4 days. With this potentiostatic approach, the amount of corrosion (as indicated by weight loss) can vary from sample to sample. As a result, the depth of attack in the HAZ will appear to be greater in samples with high weight loss than similar samples with less weight loss. To overcome this problem, CANMET agreed to carry out galvanostatic anodic dissolution testing - a methodology developed by CANMET and the Pulp and Paper Research Institute (4) which has been shown to correlate with free-corrosion tank tests (1,5) and field tests (6). With this approach, all of the samples of equal area lose the same weight during the test but the location of the material loss depends upon the relative corrosion susceptibility of various parts of the specimen.

EXPERIMENTAL

Galvanostatic anodic dissolution tests were performed on specimens containing butt welds supplied by WIC. The specimens were first ground flat and then subjected to an anodic current density of 0.88 mA/cm^2 for a period of 15 days. After this exposure, the samples were cleaned and the depth of attack was measured with a profilometer.

RESULTS AND DISCUSSION

The results of the galvanostatic anodic dissolution test performed at CANMET are listed in Table 3. These data can be compared with the results of potentiostatic anodic dissolution experiments(2,3) also listed in Table 3. The CANMET results are plotted in Fig.1 where they are compared with the trend lines obtained in the earlier study sponsored by Algoma(1). A number of interesting observations can be made concerning Fig. 1:

1) The Mn level in the baseplate is the dominant factor in determining the depth of HAZ attack. At high Mn levels, excellent agreement with the trend lines established earlier has been observed. At low Mn levels, on the other hand, the agreement is poor with the depth of attack approximately twice the value expected. It is not clear why these high purity vacuum-melted steels are prone to higher than expected HAZ attack at Mn levels in the 0.75 to 0.80% range.

2) Nb appears to have no effect on the depth of HAZ attack although metallographic data in the WIC report(2) show that Nb has a significant effect on HAZ microstructure.

3) Carbon level has no effect on the depth of HAZ attack although it obviously has a significant effect on hardenability.

4) In these steels, heat input does not have a significant effect on the depth of HAZ attack.

Photographs of the specimens after galvanostatic anodic dissolution are presented in Fig. 2.

CONCLUSIONS

A number of conclusions can be drawn from this study:

1) The galvanostatic anodic dissolution test carried out by CANMET facilitates a comparison between samples in this study and between this study and others.

2) The Mn level in the baseplate is the dominant factor controlling accelerated HAZ attack. Above some Mn level, HAZ attack is impossible to control. (The Canadian Coast Guard has chosen 1.25% Mn as the maximum allowable for repair of the icebreaker Louis St. Laurent.)

3) Because C and Nb levels do not affect HAZ attack, the hypothesis that low temperature transformation products are responsible for HAZ corrosion requires re-evaluation.

REFERENCES

1) R. J. Brigham, M. McLean, V. S. Donepudi, S. Santyr, L. Malik and A. Garner, Evaluation of Weld-Zone Corrosion of Shipbuilding Steel Plates for Use in the Arctic Environment, Can. Met. Quart.27 311 (1988).

2) Fundamental Study of HAZ Corrosion: The Effect of Microstructure, Welding Institute of Canada Report RC213.

3) G. C. Savva, G. C. Weatherly and K. T. Aust, Heat-Affected Zone Corrosion Behavior of Carbon-Manganese Steels, Corrosion 45 243 (1989).

4) A. Garner, R. J. Brigham and J. B. Gilmour, Predicting Localized Corrosion of Weldments with an Anodic Dissolution Test, Paper No. 62, CORROSION 89, NACE (1989).

5) L. D. Parkinson, L. Malik, V. Mitrovic-Scepanovic and R. J. Brigham, Evaluation of Shielded Metal Arc Welding Consumables for Repair of Weld-Zone Corrosion, Can. Met. Quart. 28 135 (1989).

6) L. D. Parkinson, V. Mitrovic-Scepanovic and R. J. Brigham, Laboratory and Field Evaluation of Weld-Zone Corrosion on the M. V. Arctic, in preparation.

Table 1

Steel Compositions (wt %)

Steel	C	Mn	Si	Nb	S	Al	Cu	Ni	Cr	V
1	0.12	0.78	0.28	0.002	0.009	0.025	0.012	0.007	0.019	0.002
1a	0.14	0.70	0.25	-	0.005	0.030	-	-	-	-
2	0.12	0.80	0.29	0.038	0.009	0.025	0.012	0.007	0.019	0.003
3	0.13	1.39	0.35	0.002	0.009	0.032	0.012	0.007	0.019	0.003
3a	0.14	1.50	0.25	-	0.005	0.030	-	-	-	-
4	0.13	1.44	0.38	0.040	0.009	0.025	0.012	0.007	0.019	0.003
5	0.055	0.78	0.31	0.002	0.009	0.015	-	-	-	-
6	0.052	0.77	0.31	0.035	0.009	0.015	-	-	-	-
7	0.057	1.54	0.31	0.002	0.009	0.015	0.012	0.007	0.019	0.004
8	0.056	1.53	0.32	0.039	0.009	0.015	0.012	0.007	0.019	0.004

Table 2

Welding Parameters

Filler Wire = SD1-3Ni
Flux = OP121TT

Weld	Current (A)	Voltage (V)	Speed (cm/min)	Nominal Heat Input kJ/mm
A	500	28	70	1.2
B	500	28	27.5	3.05

Table 3

DEPTH OF ATTACK IN THE HAZ (mm)

SAMPLE	POTENTIOSTATIC DISSOLUTION	GALVANOSTATIC DISSOLUTION					
	WIC	(Lt)	CANMET	(Rt)			
1-1	0.16	0.20		0.19			
1-3	0.14	0.18		0.18			
1a-1	0.18						
1a-3	0.16						
2-1	0.16	0.20		0.19		Nb	
2-3	0.15	0.18		0.24		Nb	Hi
3a-1	0.35	0.42		0.43			C
3a-3	0.22				Hi		
3-3	0.24	0.37		0.40	Mn		
4-1	0.25	0.41		0.40		Nb	
4-3	0.20	0.37		0.45		Nb	
5-1	0.21	0.16		0.18			
5-3	0.18	0.27		0.19			
6-1	0.41	0.21		0.23		Nb	
6-3	0.36		0.17			Nb	Lo
7-1	0.23	0.35		0.38			C
7-3	0.36	0.34		0.34	Hi		
8-1	0.49	0.51		0.57	Mn	Nb	
8a-1	0.49					Nb	
8-3	0.55	0.45		0.46		Nb	

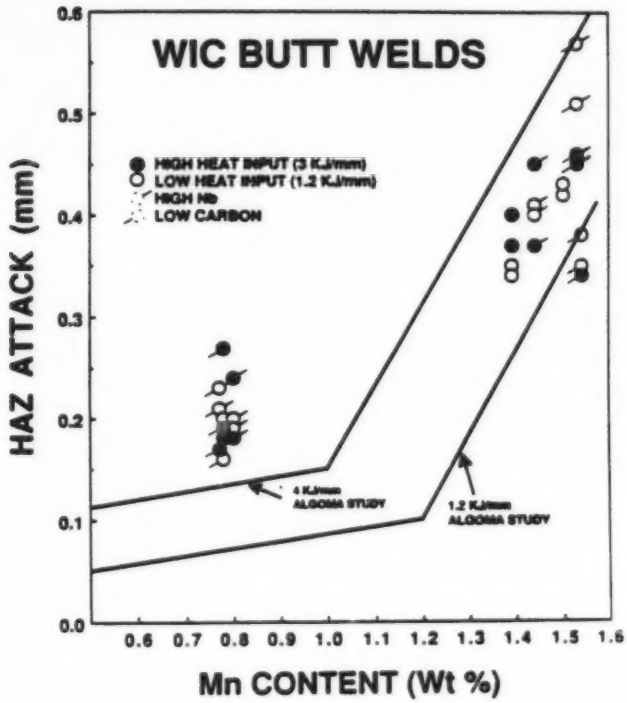

Fig.1 :Depth of HAZ Attack as Function of Mn Content Compared with Trend Lines from Algoma Study. (Neg. 19114)

Fig.2 :Photograph of Sample 1-1 (Neg. 19090)

Fig.2 :Photograph of Sample 1-3

Fig.2 :Photograph of Sample 2-1

Fig.2 :Photograph of Sample 2-3

Fig.2 :Photograph of Sample 3-1

Fig.2 :Photograph of Sample 3-3

Fig.2 :Photograph of Sample 3-1A

Fig.2 :Photograph of Sample 4-1

Fig.2 :Photograph of Sample 4-3

Fig.2 :Photograph of Sample 5-1

Fig.2 :Photograph of Sample 5-3

Fig.2 :Photograph of Sample 6-1

Fig.2 :Photograph of Sample 6-3

Fig.2 :Photograph of Sample 7-1

Fig.2 :Photograph of Sample 7-3

Fig.2 :Photograph of Sample 8-1

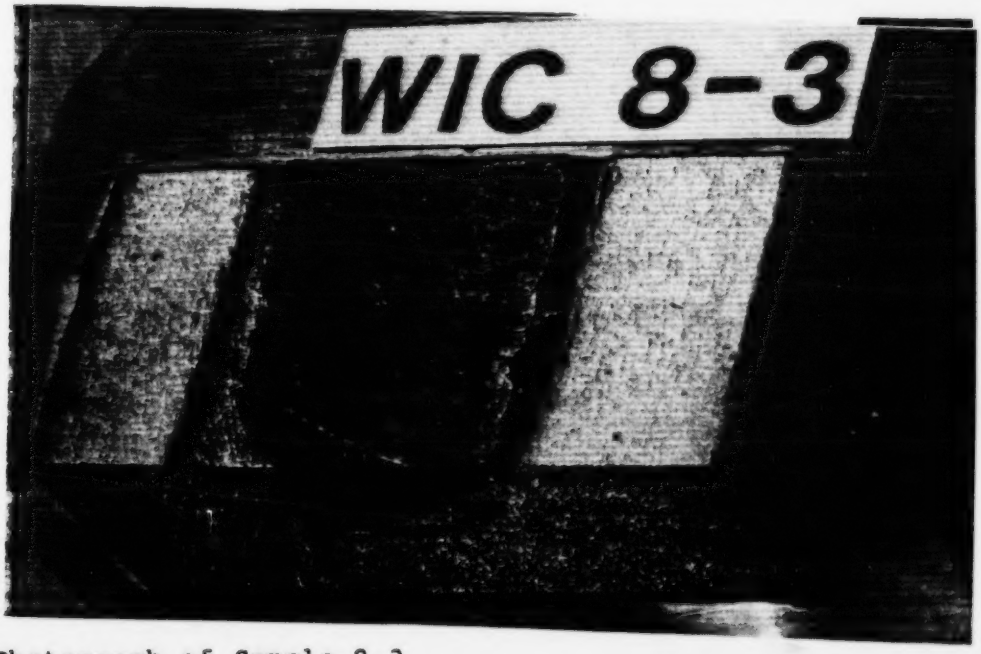

Fig.2 :Photograph of Sample 8-3